**The Hong Kong University of Science and Technology**

**ELEC 4840 Course Syllabus**

**Artificial Intelligence for Medical Image Analysis**

ELEC4840

3 credits

Prerequisites: (COMP 2011 OR COMP 2012 OR COMP 2012H) AND (MATH 2111 OR MATH 2121 OR MATH 2131 OR MATH 2350)

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**Office Hours:** Rm 2524, Wed, 3:00 - 4:00 pm

**Course Description**

Medical imaging plays a vital role in the entire spectrum of healthcare, ranging from wellness and screening to early diagnosis, treatment selection, and follow-up. In this course, we will delve deeply into the latest advancements in AI for medical image analysis, with a specific focus on deep learning techniques for disease screening and detection using medical images. The course will cover various topics, including the fundamentals of deep neural networks, the basics of medical imaging, and an exploration of state-of-the-art deep learning models in the context of different types of medical images.

The objective of this course is to equip students from diverse backgrounds with both a conceptual understanding and practical skills in cutting-edge research on AI in healthcare. By providing a comprehensive overview of the field and the fundamental techniques necessary for image processing, analysis, and scientific applications, this course aims to empower students to effectively utilize images for scientific discovery and practical purposes.

**Intended Learning Outcomes (ILOs)**

By the end of this course, students should be able to:

ILO1: Deploy the deep learning algorithms to perform fundamental image recognition tasks.

ILO2: Display proficiency in utilizing at least one of the deep learning frameworks, such as PyTorch or TensorFlow.

ILO3: Explain and analyze foundational knowledge of multimodality medical images.

ILO4: Explain, analyze, and implement deep learning basics algorithms and mechanisms.

ILO5: Explain, analyze, and implement deep learning applications in medical image analysis, such as semi-supervised learning, and domain generalizable approaches.

**Assessment and Grading**

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

**Assessments:**

| Assessment Task | Contribution to Overall Course grade (%) | Due date |
|---|---|---|
| Homework | 60% | Week 3,6,9 (3 assignments in total) |
| Final Project | 40% | Week 12 |

* Assessment marks for individual assessed tasks will be released within two weeks of the due date.

**Mapping of Course ILOs to Assessment Tasks**

| Assessed Task | Mapped ILOs | Explanation |
|---|---|---|
| Homework | ILO1, ILO2,ILO3, ILO4 | The homework assignments include hands-on coding tasks to implement deep learning algorithms (ILO1, ILO2), analysis and Q&A for basic medical images' imaging mechanisms and applications (ILO3), and applying deep learning algorithms to these medical images (ILO4). |
| Final Project | ILO3, ILO4, ILO5 | The final project involves grouping students to complete a project focusing on a specific task of deep learning-based medical image analysis. The students need to investigate the medical problem (ILO3), implement the comprehensive framework to accomplish the goal (ILO4), and write a complete report describing the problem, solution, and analyze the results (ILO5). |

**Grading Rubrics**

Final Project Grading Rubrics:

Student's proposed algorithm 1:

- 10% Soundness of the problem statement: The report introduces the topic and its importance and gives a brief literature review on the topic chosen for improvement.
- 10% Soundness of methodology: The report explains the method step by step and is understandable by graders.
- 10% Completeness of the experiments: The report shows the results in a clear, academic, and logical way, with discussions about the results.

Student's proposed algorithm 2:

- 10% Soundness of the problem statement: The report introduces the topic and its importance and gives a brief literature review on the topic chosen for improvement.

- 10% Soundness of methodology: The report explains the method step by step and is understandable by graders.
- 10% Completeness of the experiments: The report shows the results in a clear, academic, and logical way, with discussions about the results.

Student's final report writing:

- 10% Completeness of the report: Words are clear, formats are correct, and citations are proper.

Student's final project presentation:

- 20% Presentation Attendance.
- 5% Presentation materials: The presentation slides include (1) background introduction, (2) method developments, (3) results analysis, and (4) conclusion.
- 5% Presenter performance: The presenter can explain the content of the project well, and can answer the instructor's and TAs follow-up questions.

**Final Grade Descriptors:**

| Grades | Short Description | Elaboration on subject grading description |
|---|---|---|
| A | Excellent Performance | Students with excellent performance in the course demonstrate a strong grasp of the lecture contents, effectively implement the coding framework required, excel in homework implementation, and excel in the problem-solving of the final project. They exhibit exceptional software engineering ability, medical image insights, meticulous project planning, efficient teamwork, and effective leadership insights. |
| B | Good Performance | Students with good performance in the course demonstrate a solid understanding of the lecture contents, proficient use of the coding framework required, competent completion in homework implementation, and satisfactory progress in the problem-solving of the final project. They showcase commendable software engineering ability, medical image insights, effective project planning, teamwork, and leadership insights. |
| C | Satisfactory Performance | Students with satisfactory performance in the course demonstrate an adequate understanding of the lecture contents, satisfactory implementation of the coding framework required, and completed homework implementation and the final project. They demonstrate satisfactory software engineering ability, medical image insights, project planning, teamwork, and leadership insights. |
| D | Marginal Pass | Students with a marginal pass in the course demonstrate a limited understanding of the lectured contents, inconsistently implementing the coding framework required, incomplete or inconsistent homework implementation, and minimal progress of the final project. They exhibit limited software engineering ability, medical image insights, project planning, teamwork, and leadership insights. |
| F | Fail | Students who fail the course demonstrate a lack of understanding of the lecture contents and fail to implement the coding framework required, homework implementation, and the final project. They lack essential software engineering ability, medical image insights, project planning, teamwork, and leadership insights. |

**Course AI Policy**

The use of Generative AI in the project is permitted with proper acknowledgment and will NOT be contributed to the student's work.

**Communication and Feedback**

- Assessment marks for individual assessed tasks will be communicated via Canvas within three weeks of submission. Feedback on assignments will include the reason for the point deduction.
- Students who have further questions about the feedback, including marks, should consult the instructor within five working days after the feedback is received.

**Late Submission Policy**

- 3 free late days to use per assignment.
- Once free late days are exhausted, a 25% penalty per day.

**Required Texts and Materials**

Bankman, I. ed., 2008. Handbook of medical image processing and analysis. Elsevier.

Prince, J.L. and Links, J.M., 2006. Medical imaging signals and systems (Vol. 37). Upper Saddle River: Pearson Prentice Hall.

Shen, D., Wu, G. and Suk, H.I., 2017. Deep learning in medical image analysis. Annual review of biomedical engineering, 19, pp.221-248.

Chan, H.P., Samala, R.K., Hadjiiski, L.M. and Zhou, C., 2020. Deep learning in medical image analysis. Deep learning in medical image analysis: challenges and applications, pp.3-21.

Chandra, S. ed., 2021. Artificial intelligence and machine learning in healthcare. Singapore: Springer.

Xiao, C. and Sun, J., 2021. Introduction to deep learning for healthcare. Springer Nature.

**Academic Integrity**

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.